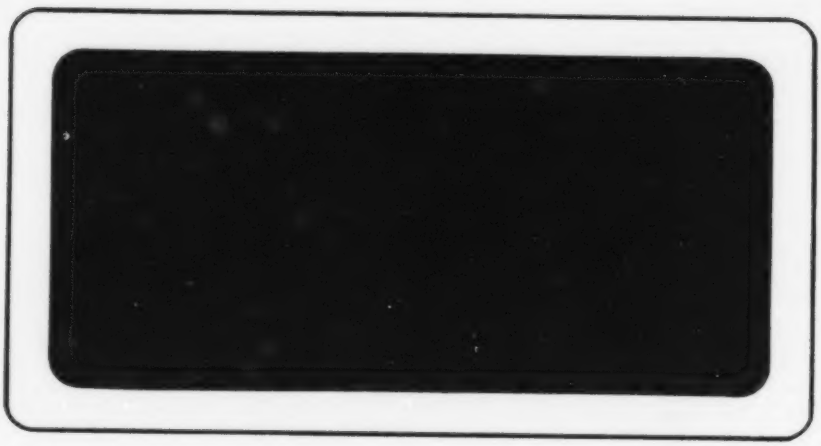

Province of British Columbia

BC Environment

WATER MANAGEMENT DIVISION

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WATER QUALITY BRANCH
MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

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AMBIENT WATER QUALITY CRITERIA FOR

pH

Prepared pursuant to Section 2(e) of the
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SUMMARY

This report is one in a series which establishes ambient water quality criteria for British Columbia. The criteria are safe conditions or levels of a variable, applicable province-wide, which are set to protect various water uses. This report sets criteria for pH or the hydrogen ion concentration to protect drinking water, freshwater and marine aquatic life, wildlife, livestock, irrigation, and recreation. The criteria are summarized in Table 1 at the back of this report.

The criteria for aquatic life are similar to the Canadian Water Quality Guidelines (CCREM, 1987), except that we have added criteria for naturally acidic (pH < 6.5) and alkaline waters (pH >9.0), and the amount of pH change allowed within the pH range 6.5-9.0 may depend on the ambient carbon dioxide concentrations. Also, any pH change that would cause chemical species (e.g., metals, ammonia-nitrogen, etc.) to exceed their criteria or objectives would not be permitted.

The recreation criteria are more liberal than the CCREM guidelines because we recognize that the pH of many interior recreational areas may have natural pH values greater than 9.0. There are no CCREM pH guidelines for marine life, livestock water supply, or irrigation for which we have set criteria.

A major use of the criteria is to set ambient water quality objectives. The objectives are the criteria modified or adopted to protect the most sensitive designated water use in a particular body of water. The objectives are used in the preparation of Waste Management Permits, Orders, or Approvals, which are the only documents to have legal standing. The objectives, however, are not usually part of these documents.

PREFACE

The Ministry of Environment is developing province-wide ambient water quality criteria for variables that are important in the surface waters of British Columbia. This work has the following goals:

(1) to provide criteria for the evaluation of data on water, sediment, and biota.

(2) to provide criteria for the establishment of site-specific ambient water quality objectives.

The ambient water quality objectives for specific water-bodies will be based on the criteria as well as on present and future uses, waste discharges, hydrology/limnology/oceanography, and existing background water quality. The process for establishing water quality objectives is more fully outlined in "Principles for Preparing Water Quality Objectives in British Columbia," copies of which are available from the Water Quality Branch of the Water Management Division.

Neither criteria, nor objectives which are derived from them, have any legal standing. The objectives can be used in calculating the limits to be allowed in waste discharges. These limits are set out in waste management permits which do have legal standing. The objectives are not usually incorporated as conditions of the permit.

The definition adopted for criteria is: " A maximum and/or a minimum value for a physical, chemical or biological characteristic of water, sediment or biota, applicable province-wide, which should not be exceeded to prevent specified detrimental effects from occurring to a water use, including aquatic life, under specified environmental conditions."

The criteria are province-wide in application, but use-specific, and are being developed for the following water uses:

-Drinking, public water supply and food processing*
-Aquatic life and wildlife
-Agriculture (livestock watering and irrigation)
-Recreation and aesthetics**
-Industrial (water supplies)

The criteria are set after considering the scientific literature, criteria from other jurisdictions, and general information on the effects of toxicants on various life forms. This information is rarely totally conclusive because it is usually based on laboratory work which only approximates actual field conditions. To compensate for this uncertainty, criteria have built-in safety factors. We use safety factors which are conservative but reflect natural background conditions in the province.

Given this procedure for setting criteria, the objectives will, in most cases, be the same as criteria. However, in some cases, such as when natural background levels exceed the criteria, the objectives could be less stringent than the criteria. In relatively rare instances, for example if the resource is unusually valuable or of special provincial significance, we could increase the safety factor by using objectives which are more stringent than the criteria. Another approach in such special cases would be to develop site-specific criteria by carrying out toxicity experiments in the field. This approach is costly and time-consuming and therefore not often used.

The criteria will be subject to review and revision as new knowledge becomes available, or as other circumstances dictate.

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* The criteria apply to the ambient raw water source before it is diverted or treated for domestic use. The Ministry of Health authorizes the use of source waters utilized for domestic waterworks systems and regulates the quality of water delivered by a water purveyor.
** Criteria relating to public health at bathing beaches will be the same as those used by the Ministry of Health which regulates their use.

RECOMMENDED CRITERIA

These criteria are based on information presented in a Technical Appendix and are summarized in Table 1.

1.0 DRINKING WATER

The pH criteria for drinking water supplies are 6.5-8.5. The criteria were adopted from the British Columbia Ministry of Health, and are the same as the CCREM guidelines. The criteria were designed to: 1) minimize the solubilization of heavy metals and salts from water distribution pipes; 2) minimize the precipitation of carbonate salts in the distribution system; and 3) maximize the effectiveness of chlorination.

2.0 AQUATIC LIFE

2.1 FRESHWATER

The British Columbia pH criteria to protect aquatic life must take into account the wide variability of the natural pH found in the freshwaters of British Columbia and the most sensitive aquatic organisms.

2.1.1 Natural pH less than 6.5

Acidic conditions are commonly found in the high precipitation areas on the west coast of British Columbia. Waters in these areas are typically acidic, and in boggy areas water can have a pH as low as 5.0 (e.g., Queen Charlotte Lowlands). These areas may have a fauna and flora that are at the low end of their pH range. To protect the aquatic communities from further acidification and possible elimination of species from the system, one component of the pH criteria for freshwater is: no statistically significant decrease from background or upstream values. See Table 1 for definition of a statistically significant decrease in pH.

In boggy areas where the fauna and flora are considered unique (e.g., ecological reserve, park, nature walk, etc.), an increase in pH could allow less acid-tolerant species to inhabit the body of water. Under these circumstances, site specific ambient water quality objectives for pH are required in order to preserve the integrity of the bog's unique fauna and flora.

2.1.2 Natural pH 6.5 to 9.0

For natural freshwaters with a pH between 6.5 and 9.0, one component of the pH criteria is : no restriction on change within this range.

Note that a pH change in freshwaters containing carbonate and bicarbonate ions will alter the carbon dioxide concentration. An increase in pH that causes the carbon dioxide concentrations to decrease below 10 µmol/L may cause a shift in the phytoplankton community structure to cyanobacteria. High concentrations of cyanobacteria can cause taste and odour problems in drinking water supplies, a muddy flavour in game fish, aesthetically unpleasant surface scums and, under rare circumstances, toxicity to livestock, dogs, or wildlife.

A decrease in pH that causes the carbon dioxide concentrations to exceed 1360 µmol/L may be toxic to aquatic life. Consequently, the pH criteria should be used cautiously in situations where the carbon dioxide concentrations could decrease below a 10 µmol/L minimum or exceed a 1360 µmol/L maximum.

2.1.3 Natural pH greater than 9.0

For freshwaters with a natural pH above 9.0, one component of the pH criteria is: no statistically significant increase over background, except for short periods of time (2-3 days maximum) in lakes or reservoirs for restoration purposes. See Table 1 for definition of a statistically significant change in pH.

Above pH 9.0, fish have difficulty excreting ammonia across the gill epithelium. Although it is uncommon to have pH ≥ 9.0, it can occur in very productive lakes, streams, and aquatic plant beds during the day because of the pH shift caused by the uptake of carbon dioxide for photosynthesis. During the night the pH of these waters can decline as much as 1 pH unit due to the dissolution of carbon dioxide from the atmosphere, the respiration of the biota, and the cessation of carbon dioxide uptake by plants. Despite these extreme diurnal pH fluctuations, fish are capable of surviving pH levels ≥9.0 for short periods of time.

The addition of lime or calcium carbonate to lakes and reservoirs has been an effective lake restoration technique to reverse the eutrophication process. Liming temporarily increases the calcium and carbonate concentrations as well as the pH of the water causing a precipitation of calcium carbonate. During the precipitation of calcium carbonate, dissolved and suspended phosphorus as well as living algal cells are incorporated within the calcium carbonate crystal and deposited on the lake bottom. The result is an improvement in water quality through a reduction in

algal biomass and phosphorus concentrations. Because of the potential importance of liming as a lake restoration technique, short term increases to pH 9.5 are acceptable as long as the elevated pH is not toxic to aquatic life.

2.2 MARINE WATERS

The need for water quality criteria for pH in marine waters has not been addressed by other jurisdictions. Based on the narrow pH tolerance of marine molluscs, and the importance of marine molluscs in British Columbia, the pH criterion for marine waters is 7.0 to 8.7.

3.0 WILDLIFE

There are no CCREM or British Columbia criteria for the protection of wildlife that may reside in or around water. The protection of fish and invertebrate species with the aquatic life criteria will ensure the protection of resident birds and mammals.

4.0 LIVESTOCK WATER SUPPLY

The British Columbia criteria for livestock water supplies are 5.0 to 9.5. The wide pH range is acceptable because pH does not interfere with the water's palatability or the health of livestock. No pH criteria for livestock water supplies were proposed by the CCREM.

5.0 IRRIGATION

The British Columbia pH criteria of 5.0 to 9.0 for irrigation recognize that soil acidity, salinity, and alkalinity are a concern in agriculture. No pH criteria for irrigation waters were proposed by CCREM.

6.0 RECREATION

Alkaline or acidic waters may cause eye irritation by causing an imbalance in the pH of the lacrimal fluid (pH 7.4) around the eye. The eye, however, has the capacity to withstand quite wide extremes in pH.

The CCREM guidelines (pH 5-9) will be adequate in British Columbia under most situations; however, the summer pH values in well-buffered acid or alkaline lakes may naturally exceed the CCREM guidelines from time to time. Acidic lakes with high buffering capacity (high organic acids) that are used for recreation (e.g., Mayer Lake, Queen Charlotte Islands) can have summer pH's as low as 4.9, while marl or productive lakes in the interior (e.g., Chilcotin, Cariboo, Thompson Plateau, Okanagan, Rocky Mountain trench), have pHs exceeding 9.0.

Because these unique systems occur naturally, they should not be in contravention of the B. C. criterion. Consequently, the B. C. criterion for recreation is : 5.0 to 9.0 with the proviso that lakes with naturally low or high pH are not in contravention of the criterion.

7.0 AESTHETICS

The British Columbia criteria recognize that marl lakes have an aesthetically pleasing colour (e.g., Kalamalka Lake), and the addition of lime or calcium carbonate to lakes can be an effective and important lake restoration technique. Consequently, temporary increases to pH 9.5 in marl or limed lakes are acceptable as long as the maximum pH is not toxic to fish. No statistically significant decrease in pH is permitted by the criteria in marl or limed lakes, in order to prevent a decrease in the carbonate concentration.

There are no CCREM guidelines for marl or limed lakes.

8.0 INDUSTRIAL WATER SUPPLY

See CCREM Canadian Water Quality Guidelines.

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Table 1

Summary of the pH Criteria

Water Use	Criteria	Comments
Drinking Water Supply	6.5-8.5	Designed to minimize solubilization of heavy metals and salts from water distribution pipes and the precipitation of carbonate salts in the distribution system, and maximize the effectiveness of chlorination. However, natural source water outside the criteria may be safe to drink from a public health perspective.
Freshwater Aquatic Life	< 6.5	No statistically significant decrease in pH from background*. No restriction on the increase in pH except in boggy areas that have a unique fauna and flora. Site specific ambient water quality objectives to restrict the pH increase in areas with a unique fauna and flora are recommended.
	6.5-9.0	Unrestricted change permitted within this range. This component of the freshwater criteria should be used cautiously if the pH change causes the carbon dioxide concentrations to decrease below a 10 µmol/L minimum or exceed a 1360 µmol/L maximum.
	>9.0	No statistically significant increase in pH from background*. Short-term increases (2-3 days) to pH 9.5 are permitted for lake restoration projects. Decreases in pH are permitted as long as carbon dioxide concentrations are not elevated above 1360 µmol/L. Carbon dioxide concentrations above 1360 µmol/L may be toxic to fish.
Marine Aquatic Life	7.0-8.7	Unrestricted change within this range (for the protection of mollusc embryo development).
Wildlife	no criteria	Adequate protection from aquatic life criteria
Livestock Water Supply	5.0 - 9.5	pH does not interfere with the palatability of water or the health of livestock.
Irrigation	5.0 - 9.0	Recognizes that soil acidity, salinity, and alkalinity are a concern in agriculture.
Recreation	5.0 - 9.0	No irritation to eyes. Note that lakes with naturally low or high pH are not in contravention of the criterion.
Industrial Water Supply	no criteria	See Canadian Water Quality Guidelines.
Aesthetics (Marl Lakes only)	9.0 - 9.5	No statistically significant decrease*. Criterion applies to marl or limed lakes only. Temporary increases in pH to 9.5 for lake restoration projects is permitted as long as the maximum pH is not toxic to fish.

* Sampling Requirements for criteria.

1) Streams: Statistical comparison of background (upstream) and downstream results should use a 1-tailed, two sample t-test, at the 0.05 probability level. The minimum sampling requirement is 5 measurements collected weekly in 30 days. The two sample t-test requires the different stations to have similar variances (use the F-test). If, at the downstream site, data from spills or discharge events are pooled with steady state data, the variance may increase and become dissimilar to the upstream site invalidating the two sample t-test. To reduce the variance, consider the data from the steady state and the event

as independent data sets. Additional pH measurements, or a pH sensor with an automatic recorder are recommended for sites subject to event-driven pH fluctuations.

2) Lakes: Same as streams or, if background stations are not available, predischarge data should be collected near the zone of influence, once every three weeks for one or two years to determine the temporal variation. A pH sensor with an automatic recorder would collect more data and provide a better understanding of the temporal variability than normal field sampling.